Evaluation of the Effect of Land-Use Activities on Sediment Quality Within the Galveston Bay System

George Guillen, Ph.D. Oceanographer, Dept. of Interior, Minerals Management Service, Environmental Coordination Section. 504-736-2865

B.S. Marine Biology - Texas A&M University at Galveston
M.S. Wildlife and Fisheries Sciences - Texas A&M University
Ph.D. Environmental Science - University of Texas School of Public Health

4.5 years - Texas Parks and Wildlife Dept: Contaminants Biologist
11.5 years - TNRCC and predecessor agencies - various responsibilities, last served as Water Section Manager - Houston Regional Office
Most Recent Job 4 months - Senior Oceanographer - Water Quality Specialist - Minerals Management Service, New Orleans.
Teaching experience: Texas A&M University, University of Houston - Clear Lake and San Jacinto College: courses in Ecology, Fisheries Science, Water Quality Management.
Certified AFS Fisheries Scientist, Certified ESA Senior Ecologist

Coauthors:

Steve Smith - Environmental Assessment Team Leader - TNRCC. B.S. and M.S. Aquatic Biology - Southwest Texas State University. 16 years experience - TNRCC and predecessor agencies.

Linda Broach - Aquatic Scientist - TNRCC , B.S. Marine Biology - Texas A&M University at Galveston. 10 years experience - TNRCC and predecessor agencies.

Leslie Whaylen - Aquatic Scientist - TNRCC , B.S. Marine Biology - Texas A&M University at Galveston. 6 years experience - TNRCC and predecessor agencies.

Sediment Quality in the Vicinity of Permitted Discharges and Selected Land-use Practices.

Galveston Bay is the largest and most productive estuary in Texas. The introduction of anthropogenic contaminants into certain portions of the estuary is suspected to be a major factor in the decline in species diversity in these areas. Estuaries are the eventual repository for the contaminants that are either discharged directly into these unique environments or delivered indirectly by tributary streams and rivers. These contaminants are often preferentially associated with suspended sediments and are eventually deposited on the bottom. These sediments can serve as potential sinks and sources for pollutants. The evaluation and management of these contaminants has been problematic due to their persistent nature and patchy distribution. Once contaminated sites are discovered, the remediation process can often be quite lengthy and technologically difficult.

The primary objective of this study was to characterize the potential relationships between various shoreline human activities on contaminant levels, sediment toxicity, and benthic communities in adjacent waterbodies. In addition, relationships between surrounding land-use, both far-field and near-field, and these parameters were evaluated. The sediment quality triad approach was used to evaluate potential mechanisms and sources responsible for observed levels of contaminants, toxicity and benthic community composition. The EPA EMAP benthic index, a contamination score (CS = exceedances of NOAA, TNRCC and EPA screening criteria) and toxicity score (TS = # of toxic responses to 3 bioassay tests (sheepshead acute test, mysid chronic and acute, and Microtox bacterial test) was used to construct the sediment quality triad. The final objective of this study was to evaluate the practicality, accuracy and predictability of various contaminant and toxicity scoring methods for evaluating benthic community response. The intent was to begin laying the groundwork for the development of future sediment quality criteria.

The results of this study illustrate the potential influence of various industries and land use practices on sediment contamination and resulting impacts on benthic communities. However, site specific differences due to surrounding land-use and loading into the watershed will modify these impacts. For example, open bay sites were, in addition to being located far from point sources, are also found in areas with little surrounding land. They therefore possessed a higher potential for greater dilution. Only general patterns, not definitive rules regarding the relationship between shoreline land use and industries and sediment contamination, toxicity and benthic communities were discovered during this survey.

In general, spatial patterns in benthic communities revealed by cluster analysis, yielded logical groupings of stations (clusters) that correlated well with patterns in chemical contamination and toxicity. We found two groups, clusters 1 and 3, containing chemical handling facilities, ship maintenance facilities, and 1 domestic wastewater treatment plant (Table 1). These sites generally in addition to having degraded benthic communities also contained a high degree of contamination and toxicity (Figs. 1-6). Based on the results of our survey additional consideration of the effects on sediment contamination and benthic communities should be taken into account by water quality managers when evaluating the siting and operations of ship maintenance, chemical industry, and at least some wastewater treatment plant facilities. Investigators should however be careful when evaluating these sites, since previous land use practices, watershed loading, and modifying variables (e.g. dissolved oxygen) may influence present day contaminant levels, benthic communities and toxicity observed at these sites (Fig. 7 and 8).

Based on our study and the development of sediment assessment tools by EPA and NOAA status and trends programs and others, it is now possible at this time to begin to construct technically defensible sediment quality screening levels based on biologically relevant endpoints and chemical equilibrium partitioning theory. Eventually after additional research, site specific (e.g. Texas estuaries) chemical screening criteria and/or approaches could be incorporated into an existing water quality standards program. A variety of approaches ranging from specific numerical criteria to a tiered risk assessment approach similar to the U.S. Army Corp of Engineer's evaluation of dredge material discharges could be developed. This would however be a very lengthy process. Various site specific conditions (e.g. salinity, currents, physical and chemical sediment characteristics), often have a strong modifying influence of in-situ sediment chemistry and/or toxicity. The implementation of control measures (via permitting or land use control) necessary to meet standards would be at this time difficult due to our incomplete understanding of the relationship of between water quality and contaminant partitioning between water and sediment.

Careful consideration of the impacts of dredging near outfalls and adjacent areas contributing significant amounts of contaminants is warranted. Current dredging practices usually rely on mid-stream estimates of sediment contamination and do not look at the potential impacts of dredging contaminant "hot spots". Specifically the TNRCC may want to re-evaluate and/or modify current guidance on water quality certification (401 certification) of dredge projects (404 permits) near land-use activities identified in this report as having a higher likelihood of causing water quality problems if disturbed.

Further research on watershed transport and deposition of sediment bound contaminants is also needed. The major focus on water quality monitoring and modeling has historically focused on water column effects and not on the potential linkage between suspended particles and bound contaminants. This relationship has practical implications during the TMDL process. Transport and loading of contaminated sediments may not violate current water quality standards but may create "hot zones" in depositional areas located in estuaries. Some parts of Galveston Bay and other Texas estuaries are particularly vulnerable since a large amount of sediment is transported from the highly urbanized and industrialized tributaries.

Finally, extensive research is needed to better define the relative contributions of near-field sediment sources (e.g. discharges, spills etc) and watershed level loading (point and non-point sources). It is recommended that additional monitoring around fewer sites along with depositional contaminant loading studies would help answer many of the questions raised during our study. Specifically, how extensive is the sediment contamination around some of the sites we identified? Do they extend beyond the legally defined "mixing zone" which has been developed primarily to address water column impacts.

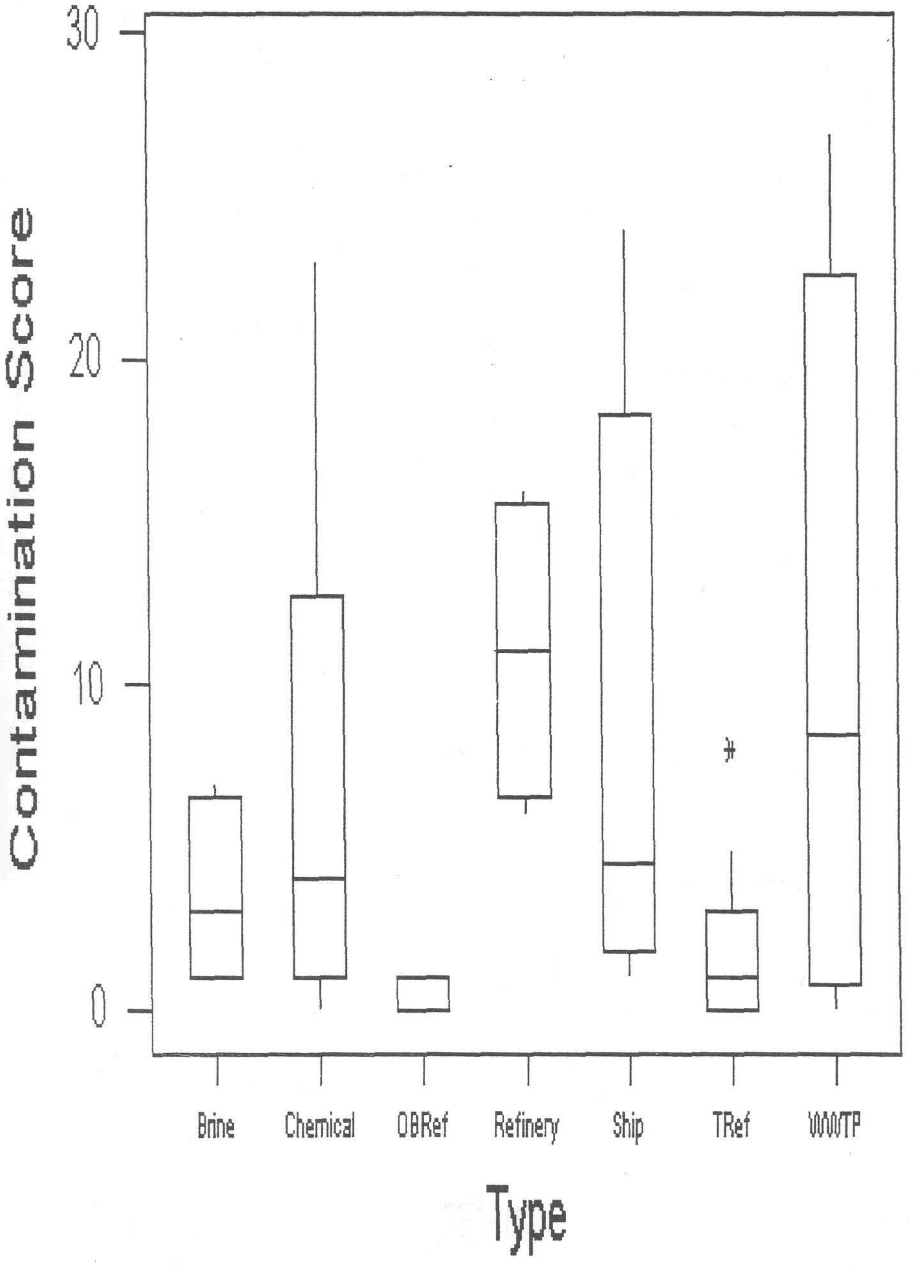

Figure 1. Contamination scores at each station type. Middle line in box denotes median, upper and lower bounds enclose (Q1) 25th and (Q3) 75th percentiles, whiskers = Q1 or Q3 +/- (Q3-Q1), outliers are denoted by asterisks.

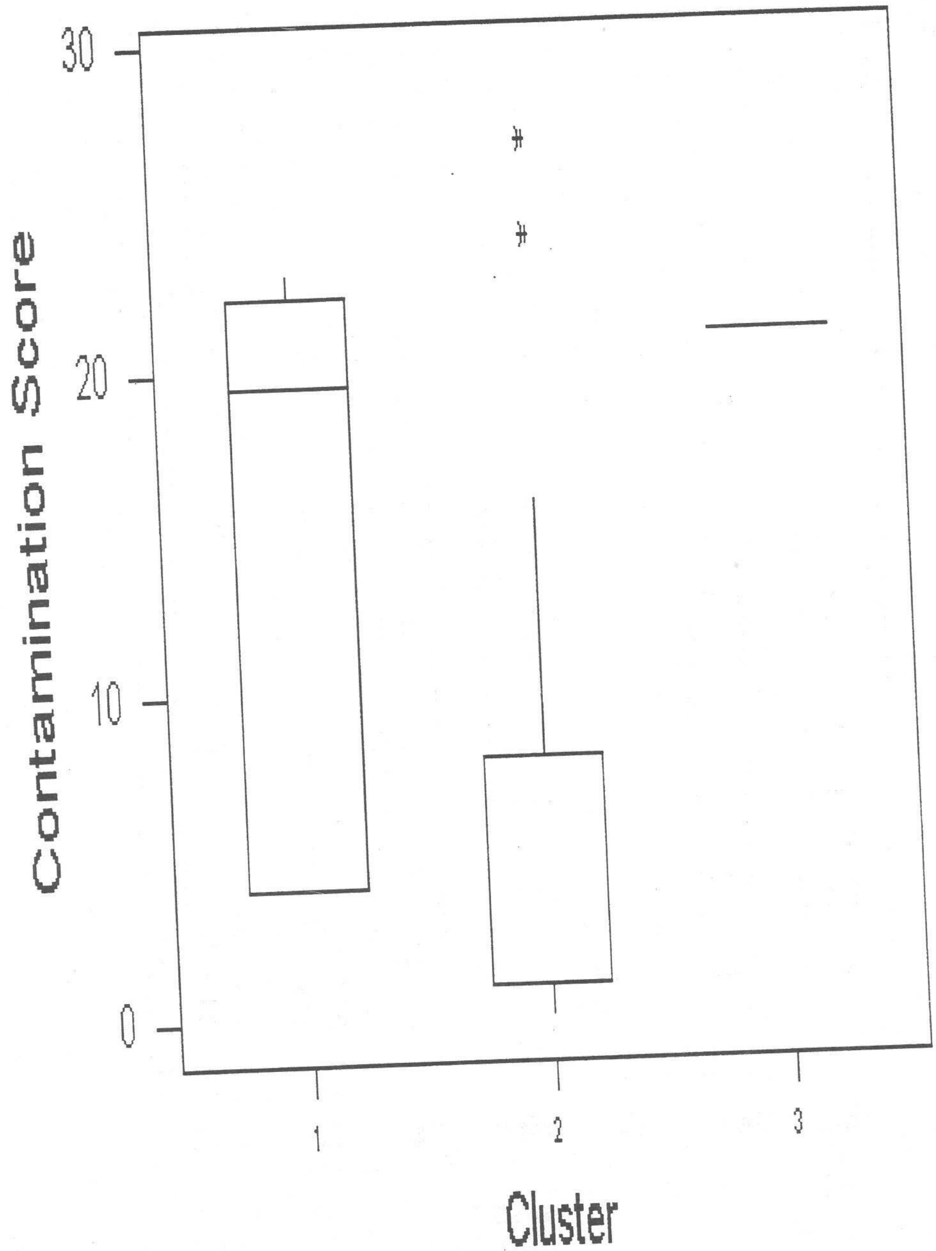

Figure 2. Contamination scores as station clusters.

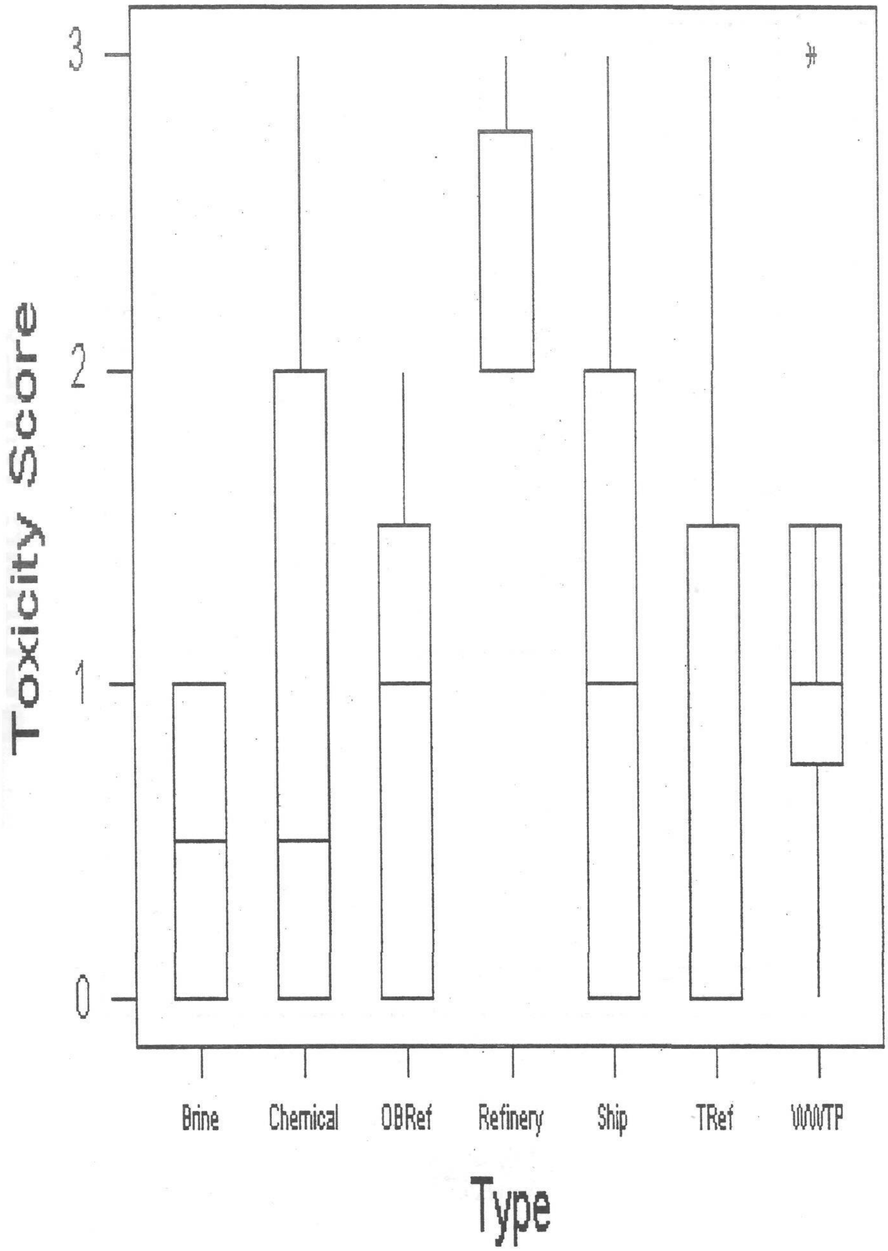

Figure 3. Toxicity scores at each station type.

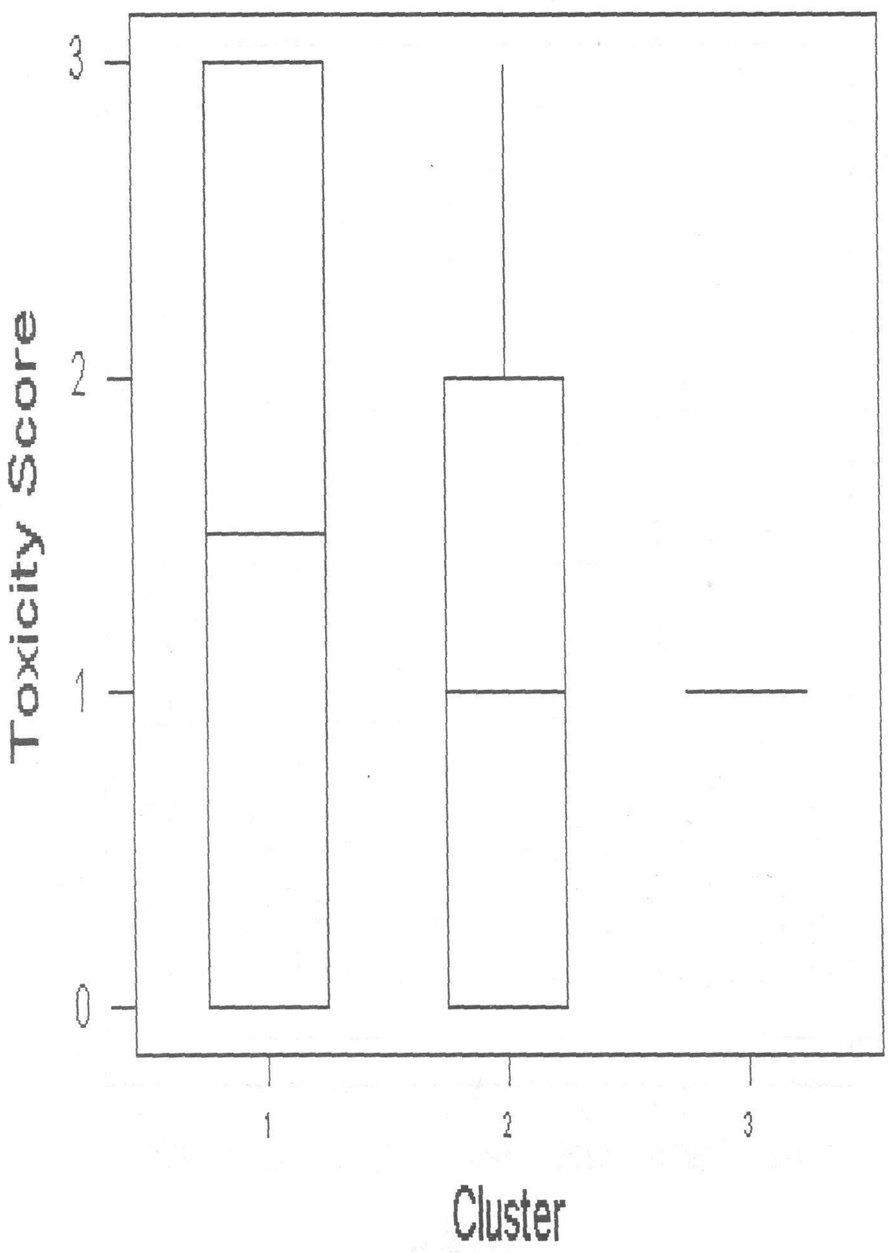

Figure 4. Toxicity scores at each station cluster.

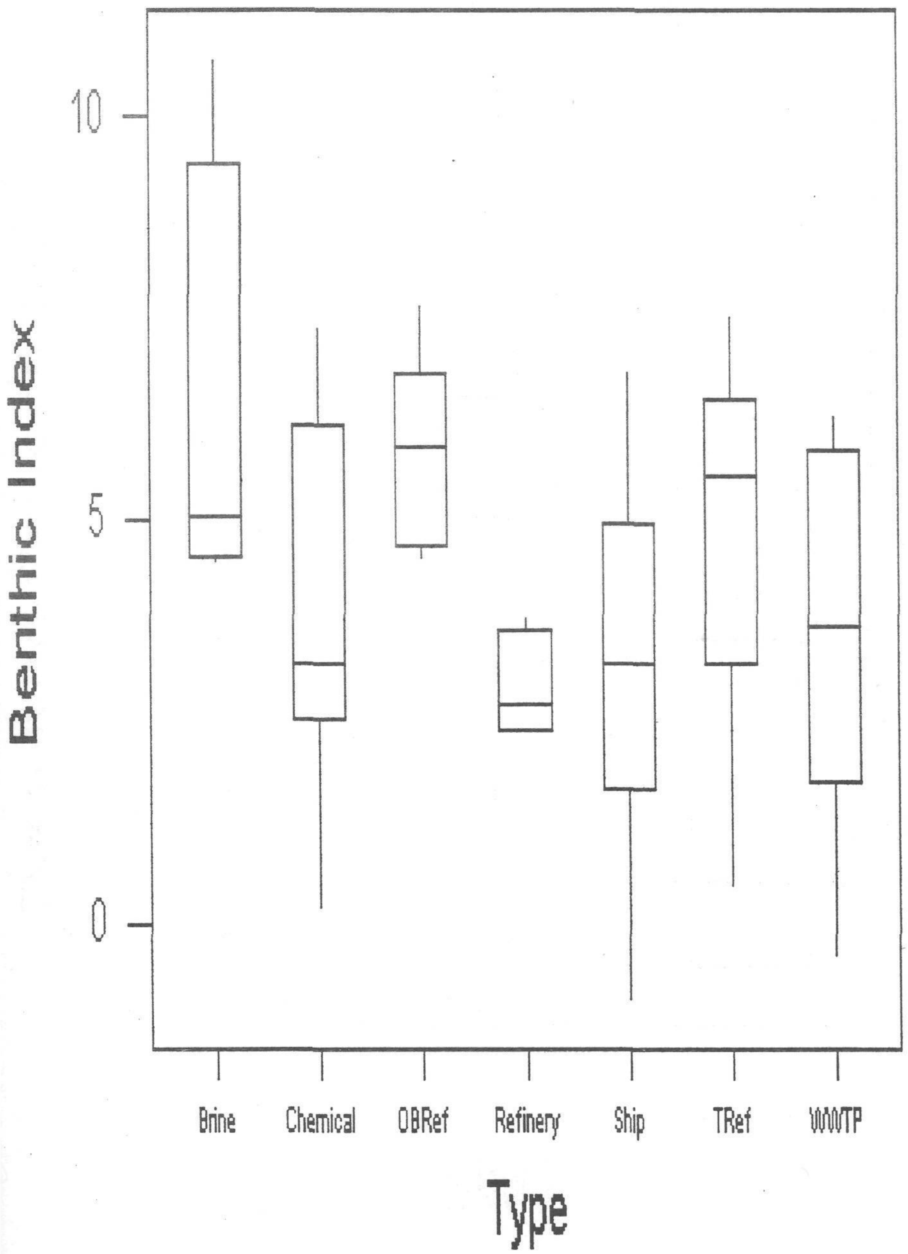

Figure 5. Benthic index scores at each station type.

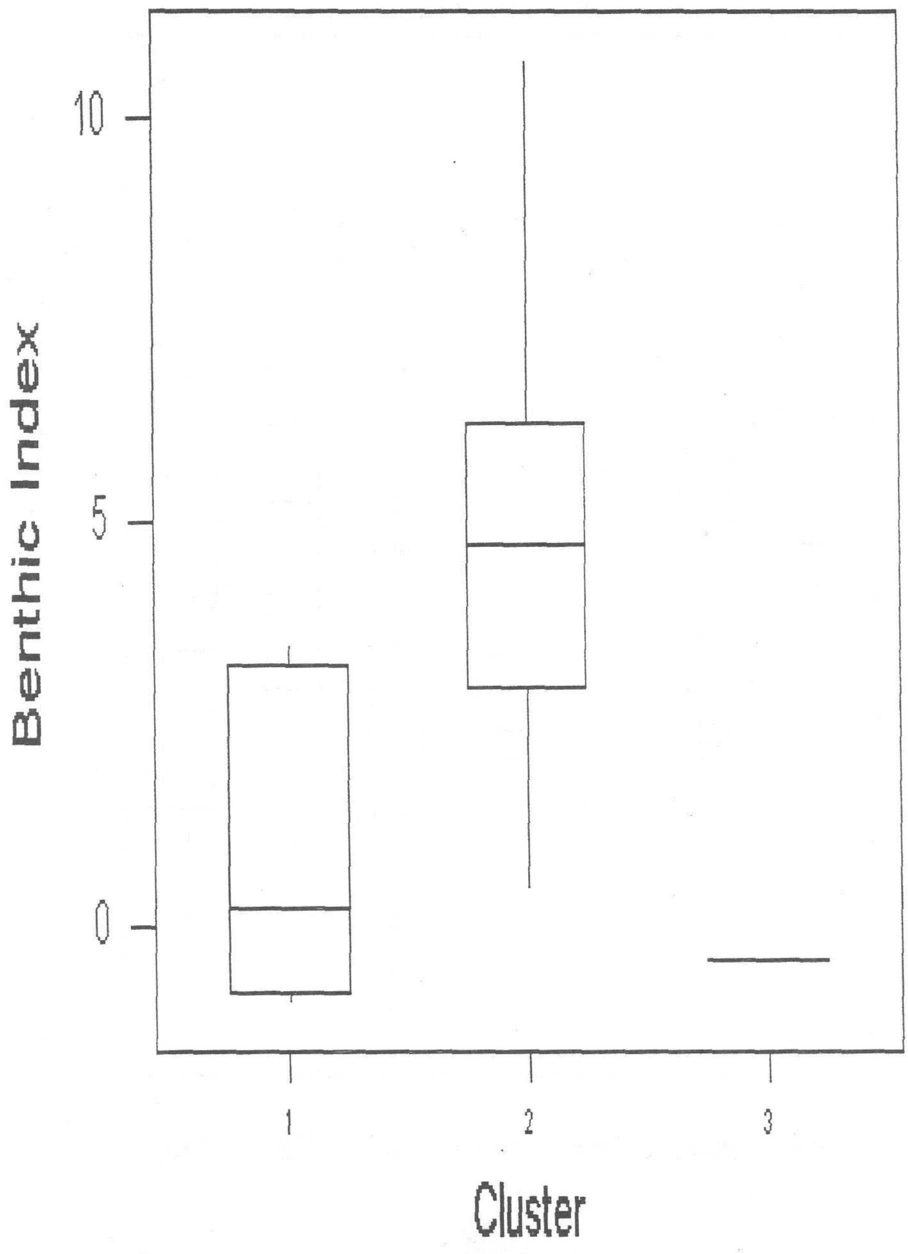

Figure 6. Benthic index scores at each station cluster.

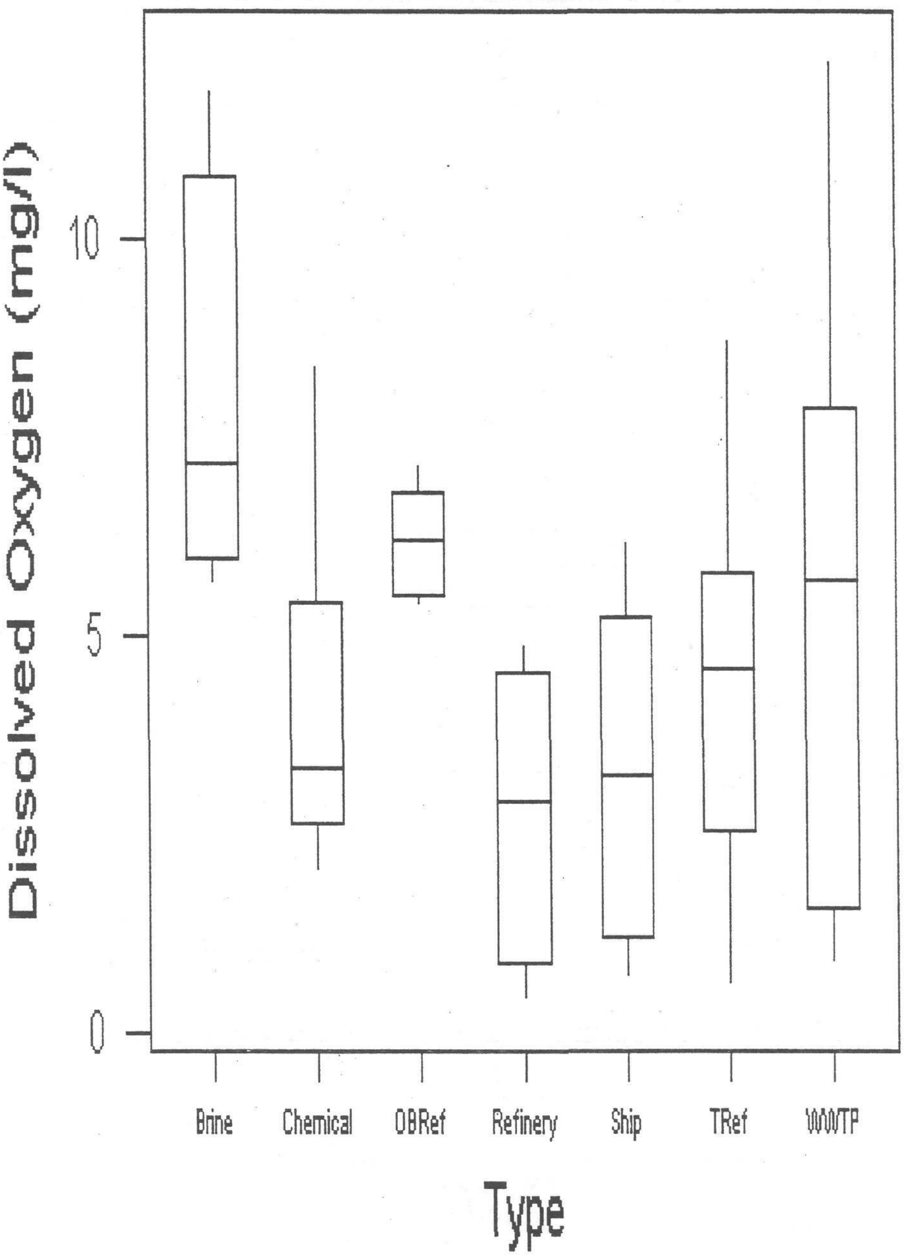

Figure 7. Bottom dissolved oxygen levels at each station type.

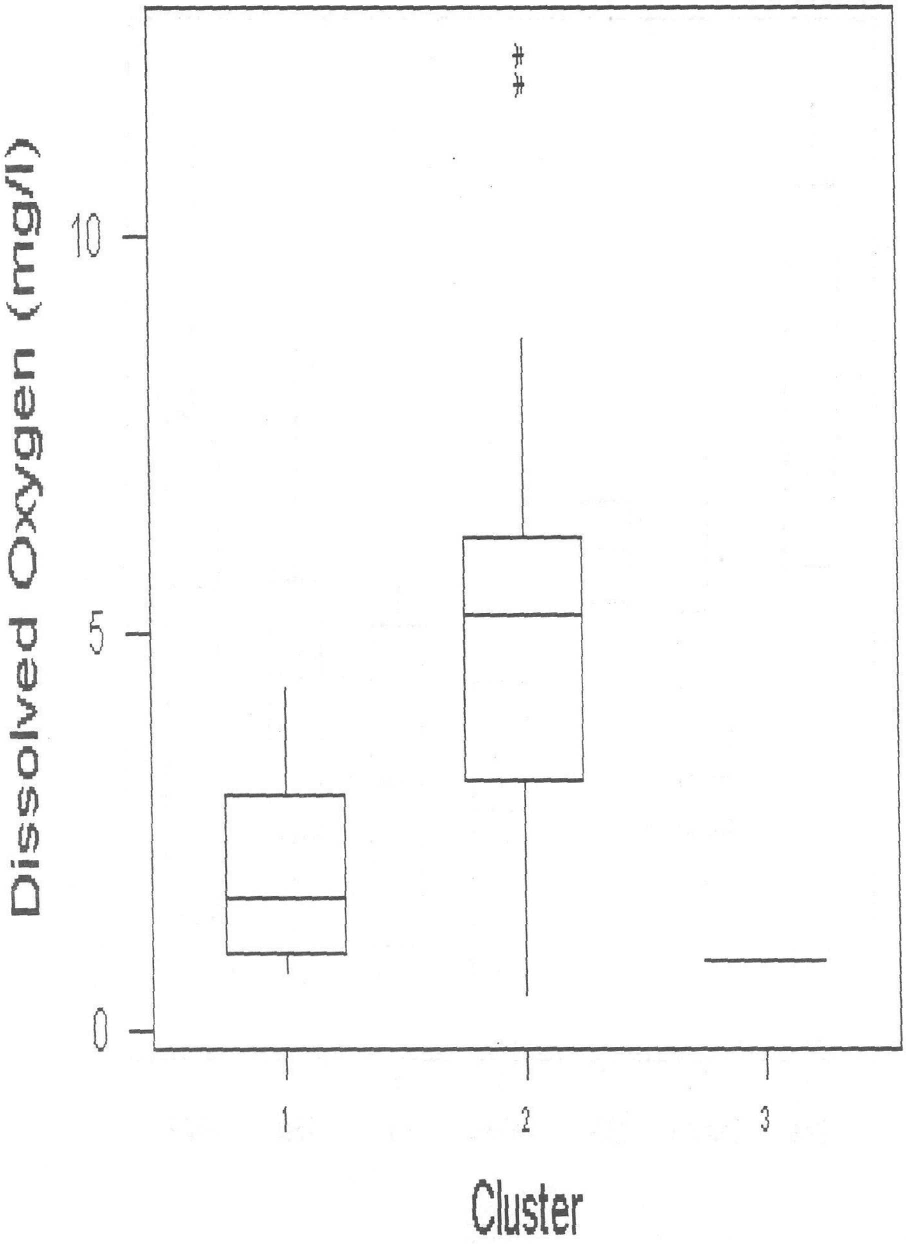

Figure 8. Bottom dissolved oxygen levels at each station cluster.